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BY

J. J. BEAN

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MILLING METHODS AT THE OXIDE CONCENTRATOR OF THE INTERNATIONAL SMELTING CO., TOOELE, UTAH[1]

By J. J. Bean[2]

INTRODUCTION

This paper, describing the milling practice at the oxide concentrator of the International Smelting Co., is one of a series on milling methods and costs being published by the United States Bureau of Mines.

GENERAL DESCRIPTION

The oxide concentrator is properly an integral part of the Tooele plant of the International Smelting Co., located 5 miles from Tooele, Tooele County, Utah.

It has a capacity of 300 tons of ore per day and uses an all-flotation process to treat custom siliceous oxidized lead ores obtained principally from the Tintic district in Utah. Ores found amenable to the process are purchased on a custom basis, the principal tonnages being obtained from the Tintic Standard and North Lily mines.

The concentrator is located on a hillside. It comprises fine-grinding, flotation, filtering and drying equipment, together with the necessary conveying, elevating, and pumping equipment necessary to connect all these departments and to supply crude ore to the fine-ore bins. No crushing or dry-sampling equipment is provided, as all ore is crushed by a Symons cone crusher set at three-eighths inch before going to the concentrator, either by a custom sampling works or by the smelter sampling mill.

Water is supplied from a reservoir previously constructed to serve the lead-zinc concentrator at the plant. This reservoir is supplied with water by various springs in canyons adjacent to the plant.

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6759."

2/ One of the consulting engineers, U. S. Bureau of Mines, and assistant concentration engineer, International Smelting Co.

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Electric power is used for operation and is supplied by the Utah Power & Light Co. at 44,000 volts. The voltage is reduced to 2,200 by an outside substation, at which voltage all motors above 50 hp. are supplied. For smaller motors and lighting the voltage is further reduced to 440 or 110 by suitable transformers within the mill itself.

ORES TREATED

As previously stated, the ores treated are from the Tintic Standard and North Lily mines. They may be characterized as oxidized, highly siliceous lead-silver-bearing ores of an earthy brown color. The following is a typical analysis:

Copper	percent...	0.21
Lead	do. ...	18.95
Zinc	do. ...	.78
Iron	do. ...	6.50
Lime	do. ...	4.17
Insoluble	do. ...	56.80
Gold	ounces per ton...	.05
Silver	do. ...	23.38

The copper occurs chiefly as chalcopyrite, chalcocite, and tetrahedrite. The lead occurs as galena, cerussite, anglesite, and to a lesser extent plumbojarosite, the first two minerals mentioned predominating. The principal silver mineral is cerargyrite; appreciable amounts of proustite and argentojarosite are also present. The gold is associated with the principal copper and lead minerals and pyrite; varying amounts are present as tarnished native gold. The gangue is principally a rather opaque quartzite but also includes oxidized iron minerals, dark colored cherts, lime, and gypsum. The ore is readily ground but owing to the high cerussite content is difficult to classify efficiently.

HISTORY OF CONCENTRATOR OPERATIONS

Present flotation operations are the outgrowth of an unbalanced silica load at the lead smelter and a resulting desire to reject some of the silica in the oxidized siliceous ores received at the smelter before sending them to the lead plant for smelting.

Various methods of concentrating were tested at the company concentration laboratory before the present successful method was evolved in the fall of 1927. During the winter of 1927-28 various ores that might be available were tested in the concentration-department continuous testing plant, and in March 1928, a full-scale mill test was commenced, using a section of the lead-zinc concentrator. After several months of this operation, during which time many operating difficulties were presented and overcome, sufficient information was obtained to design a mill especially for the treatment of oxidized ores.

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Construction of the present mill was commenced in February 1929, and the mill started operation in the latter part of June of the same year. Operation was continuous until the end of 1929, when depressed metal markets resulted in intermittent operations until the present time. Operations in the new concentrator have been successful from the first, and only reduced tonnages of ore have caused the irregular operation.

PRESENT METHOD OF CONCENTRATING

Referring to figure 1, ore as received either from the custom sampler or the smelter sampling mill is dumped into any or all of twelve 125-ton-capacity receiving bins arranged in two parallel rows of six bins each. From these bins it may be drawn out in any desired proportion onto a collecting conveyor by means of constant-speed feeder belts on the bottoms of the bins and variable opening gates on the bins themselves. This collecting conveyor belt discharges onto a cross belt which conveys the ore to the boot of a 30-inch elevator equipped with a double row of 14- by 7-inch malleable iron buckets. This elevator discharges the ore upon a 20-inch inclined belt which conveys it 504 feet over the tracks of the Tooele Valley Railway and up to the ball-mill feed bins at the top of the mill.

There are two ball-mill feed bins constructed of steel and having a capacity of 200 tons each. The No. 1 bin is filled directly from the inclined conveyor, while the No. 2 bin is filled from the inclined conveyor by means of a short horizontal conveyor belt 20 inches wide, running across the tops of the bins and discharging at the center of the No. 2 bin. Both feed bins are equipped with feeder belts and gates so that any convenient rate of discharge may be obtained. Both feeder belts discharge onto the ball-mill feed belt which is on a slight incline and discharges into the ball-mill scoop housing. Ore on this feed belt is weighed on a Biehler weightometer before passing to the ball mill.

GRINDING

Fine grinding is done in one No. 86 Marcy ball mill operating in closed circuit with an 8-foot by 23-foot 4-inch Dorr duplex classifier, model D. Normal feed rate is 300 wet tons per 24 hours. Cast-steel balls, 3-inch diameter, manufactured by the Anaconda Copper Co. at its Anaconda foundry, are used. Inasmuch as the ball mill has considerable capacity in excess of the flotation equipment, a somewhat light ball load of about 11 tons is carried. The pulp in the ball mill is carried at a density of about 80 percent of solids; that of the classifier overflow is maintained at about 26 percent of solids.

Screen analyses of ball-mill feed, classifier overflow, and flotation tailings are given in table 1.

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FLOTATION

Flotation is carried on in four 18-inch M.S. Sub-A flotation machines, operating in parallel, the feed being provided to the four machines by means of a mechanical distributor of a design developed by the company and built in its shops. Each machine has 14 cells, the first three of which are used for flotation of sulphide minerals and the last 11 of which are devoted to the flotation of oxidized minerals.

Table 1. - Screen analyses of concentrator products

Screen size	Weight, percent		
	Ball-mill feed	Classifier overflow	Flotation Tailings
+0.525 inch	0.64	--	--
+0.371 do.	4.89	--	--
+ 3 mesh	9.57	--	--
+ 4 do.	11.75	--	--
+ 6 do.	9.98	--	--
+ 8 do.	8.96	--	--
+ 10 do.	4.48	--	--
+ 14 do.	.14	--	--
+ 20 do.	.08	--	--
+ 28 do.	15.67	--	--
+ 35 do.	3.88	--	--
+ 48 do.	3.49	--	--
+ 65 do.	3.04	1.6	2.8
+ 100 do.	3.84	7.2	13.0
+ 150 do.	2.53	8.2	14.4
+ 200 do.	2.96	10.2	15.0
- 200 do.	14.10	72.8	54.8

Referring to figure 2, the feed to a flotation machine enters the second cell through a feed box and pipe; ethyl xanthate, amyl xanthate, and sodium silicate are also fed to the feed box. The second and third cells are sulphide roughers, the concentrates from these two cells being cleaned in the first cell. Cleaner cell tailings flow, as usual, to the second cell. The fifth and sixth cells produce finished oxide concentrates; cell 7 to 9, inclusive, produce rougher concentrates which are cleaned in the fourth cell. The froths of the remaining cells, 10 to 14 inclusive, are returned to the head of the oxide circuit for retreatment. Low-head air lifts are used for the return of all middlings and concentrates which require pumping in order to get them to their proper destinations.

REAGENTS

The reagents used comprise sodium amyl xanthate, 1.5 pounds per ton; sodium sulphide, 6.0 pounds per ton; sodium silicate, 4.0 pounds per ton; ethyl xanthate, 1.2 pounds per ton; and pentasol, used as a frother, 0.30

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pound per ton. The stage addition of reagents into the early part of the flotation operation is practiced, the principal amounts being added to the fifth cell which is the head of the oxide circuit.

All water-soluble reagents are fed in solution, being dissolved in large tanks on the top floor of the mill. From these mixing tanks they are drawn to the proper feeders, which are located on a floor above the flotation machines. The feeders used were developed at the plant and are of the disk-and-cup design. By means of extra long pins in the disk they feed to six places at one time. Inasmuch as the amyl xanthate and sodium sulphide must be added in stages to effect efficient flotation, enough feeders for these reagents are provided to feed to each cell down to the twelfth cell, if necessary. Other reagents require less complete staging and are consequently provided with fewer feeders.

Changes in operating conditions are met by varying the amounts of sodium sulphide added to the various cells, the amounts of ethyl xanthate, amyl xanthate, sodium silicate, and pentasol remaining essentially constant over a wide range of different ores.

AIR

Air is supplied to the flotation machines at a pressure of 1 pound per square inch by either of two No. 5 Roots blowers. Either blower has greater capacity than is needed, so the other one is held in reserve. High-pressure air for the air lifts is supplied from the smelter high-pressure service line.

METALLURGICAL RESULTS

Analyses and percent recovery or distribution in flotation heads, concentrate, and tailing for September 1930, are given in table 2.

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Table 2. - Analyses and recovery or distribution in concentrator products

	Weight, percent	Analyses						Recovery or distribution, percent					
		Percent				Ounces per ton							
		Copper	Lead	Iron	Insoluble	Gold	Silver	Copper	Lead	Iron	Insoluble	Gold	Silver
Heads	100.0	0.18	18.43	7.32	56.35	0.0567	24.85	--	--	--	--	--	--
Lead concentrate	37.09	.36	47.02	13.94	16.73	.114	58.76	72.2	94.6	43.7	11.0	74.6	87.7
Tailing	62.91	.08	1.58	6.56	79.69	.023	4.87	27.8	5.4	56.3	89.0	25.4	12.3

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DEWATERING AND HANDLING CONCENTRATES

The finished concentrates are conveyed to the boot of an elevator which elevates them high enough to allow them to run by gravity to a 50-foot Dorr tank adjacent to the filter building for thickening before filtering. A 3-inch Wilfley pump is also available for this service and is used as a stand-by for use in emergencies.

The concentrate pulp, thickened from about 25 to 50 percent of solids, is discharged directly to the boot of an elevator which conveys it to the top of the filter building where it flows by gravity to any or all of the three 6-leaf 8-foot diameter American filters. A 3-inch Wilfley pump is provided to replace the elevator in case of emergency. The filters discharge onto a reversible conveyor belt which in turn discharges either to a dryer or onto a car-loading belt which also serves the dryer.

A vacuum of 20 to 23 inches of mercury is maintained at the filters by one of two 20- by 12-inch duplex Ingersoll-Rand vacuum pumps. The filters have a capacity of 225 tons per filter day of 24 hours; moisture in filter cake varies from 13 to 15 percent.

In case of failure at the dryer or if the concentrates are to be stored in stockpiles, the reversible conveyor under the filters is set to discharge directly onto the car-loading conveyor and the filter cake, without further drying, is thus loaded directly to railroad cars.

Because of the sticky character of the concentrates after filtering drying is necessary to produce a product that may be handled at the lead-plant bins. For this purpose an 8- by 72-foot Vulcan dryer of the rotary-kiln type is provided. This dryer is brick-lined and gas-fired, natural gas being used as fuel. Filter cake from the filters on the floor above is fed into the upper end of the dryer through a chute, and as it works down the dryer to the discharge end is dried by a current of hot gas traveling countercurrent from the gas-fired furnace at the discharge end. Moisture in final product is held at about 6.5 percent in the interest of economy. With such a final moisture a granular product is obtained which is easily handled in the bins at the smelter.

DUST COLLECTOR

A cyclone-type dust collector is provided in the dryer stack to prevent excessive dusting losses in flue gases. The dust recovered per day amounts to about 300 pounds.

The dryer as previously mentioned discharges onto the car-loading conveyor which carries the concentrate to railroad cars for transportation to the smelter.

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DEWATERING AND DISPOSAL OF TAILINGS

Tailings flow by gravity from the flotation machines to a 50-foot Dorr thickener placed in line with and about 100 feet from the thickener building. The pulps are thickened only enough to supply sufficient water for milling, which means a spigot product containing about 40 percent of solids. This sounds like a peculiar statement, but due to the fact that considerable fresh water in the form of compressor, vacuum-pump, and reagent-mixer cooling water enters the circuit at all times the return water is in the nature of "make-up" water.

The overflow from the thickener, together with concentrate-tank overflow, is pumped to an equalizer tank above and in the rear of the concentrator by two 5-inch, type LV, Cameron single-stage pumps direct driven by a 50-hp., 2,200-volt, 1,750-r.p.m. motors. Only one pump is required for this service at one time.

The spigot product of the thickener is discharged directly into the tailing launder and flows by gravity to the tailing pond. No attempt is made to reclaim water from this pond.

SAMPLING

All sampling is done by Galligher automatic samplers. The heads are sampled just after overflowing the classifier, the concentrates just after leaving the flotation machines, and the tailing just after leaving the flotation machines. The products are sampled as a whole, no attempt being made to take regular samples of the products of the individual flotation machines. The products of each shift are sampled and assayed separately so that each foreman knows the metallurgical results which were obtained on his shift, and thus can better control daily operation.

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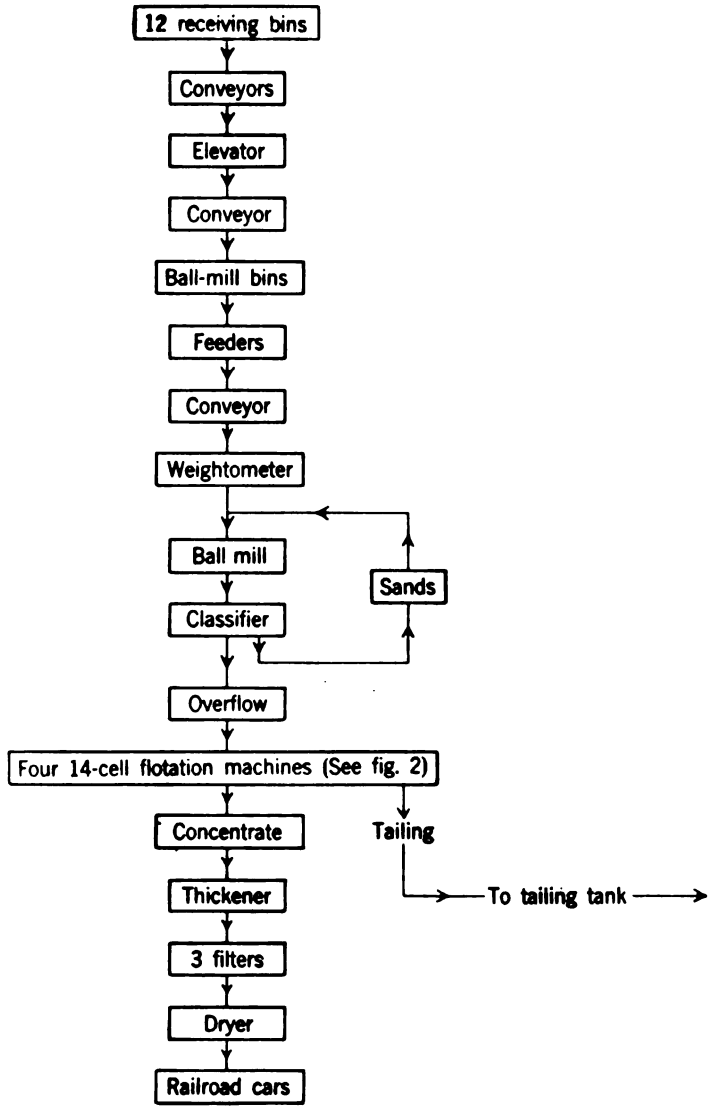

Figure 1.—Flow sheet of ore treatment.

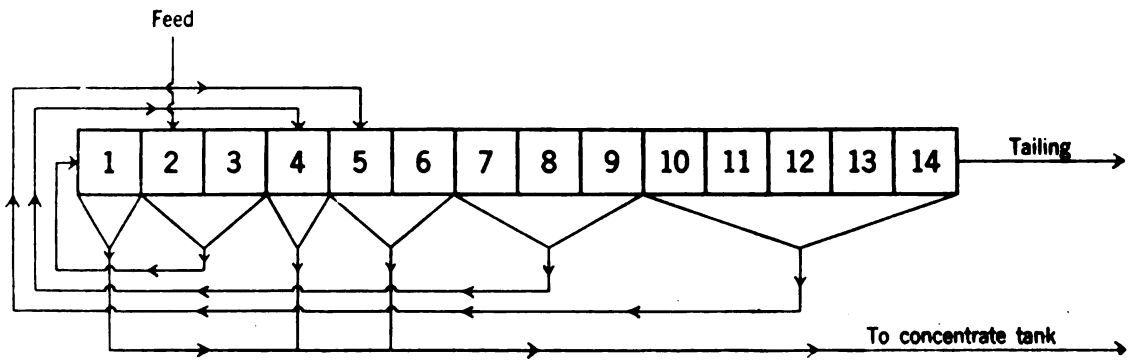

Figure 2.—Method of operating flotation machines.

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